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(54) **TRANSFERRING VERIFIABLE ADDRESS RIGHTS BETWEEN DEVICES OF A DATA CENTER (DC) NETWORK**

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H04L 61/5007 (2022.01)
H04L 101/622 (2022.01)

(52) **U.S. Cl.**
CPC ***H04L 63/10*** (2013.01); ***H04L 61/5007*** (2022.05); *H04L 2101/622* (2022.05)

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See application file for complete search history.

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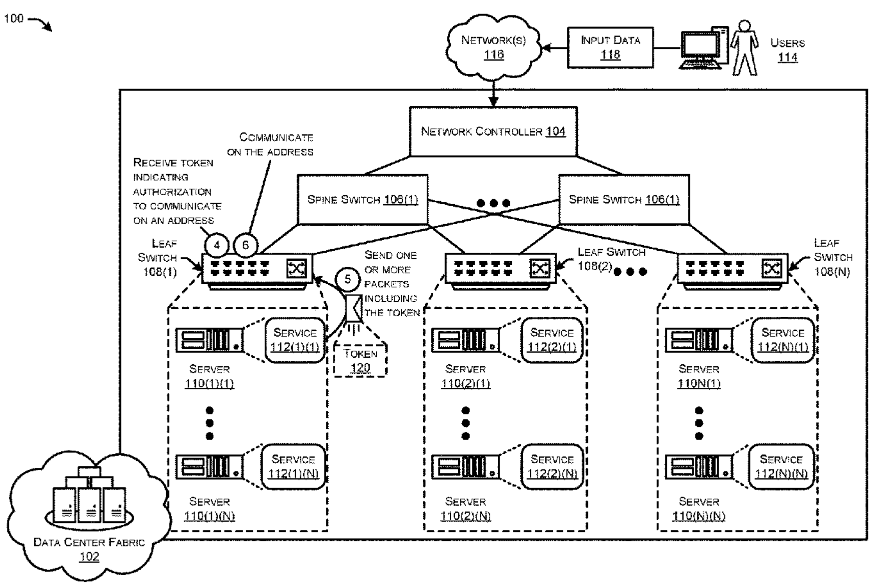
(57) **ABSTRACT**

Techniques for transferring address rights (e.g., internet protocol address(es), media access control address(es), etc.) amongst devices in a data center network fabric. A data center (DC) authority (e.g., network controller and/or a service controller) of a data center network fabric may determine that a device in the network is to communicate on an address in the network. The DC authority may create and sign a token that indicates a verifiable authorization to communicate on the address. The token may allow any device that posses the token to communicate on the address, following verification from an associated network switch. Additionally, the token may be signed by a device in the network in possession of the token, and delegated to another device in the data center network fabric following a migration of a service from one server to another, for example.

20 Claims, 7 Drawing Sheets



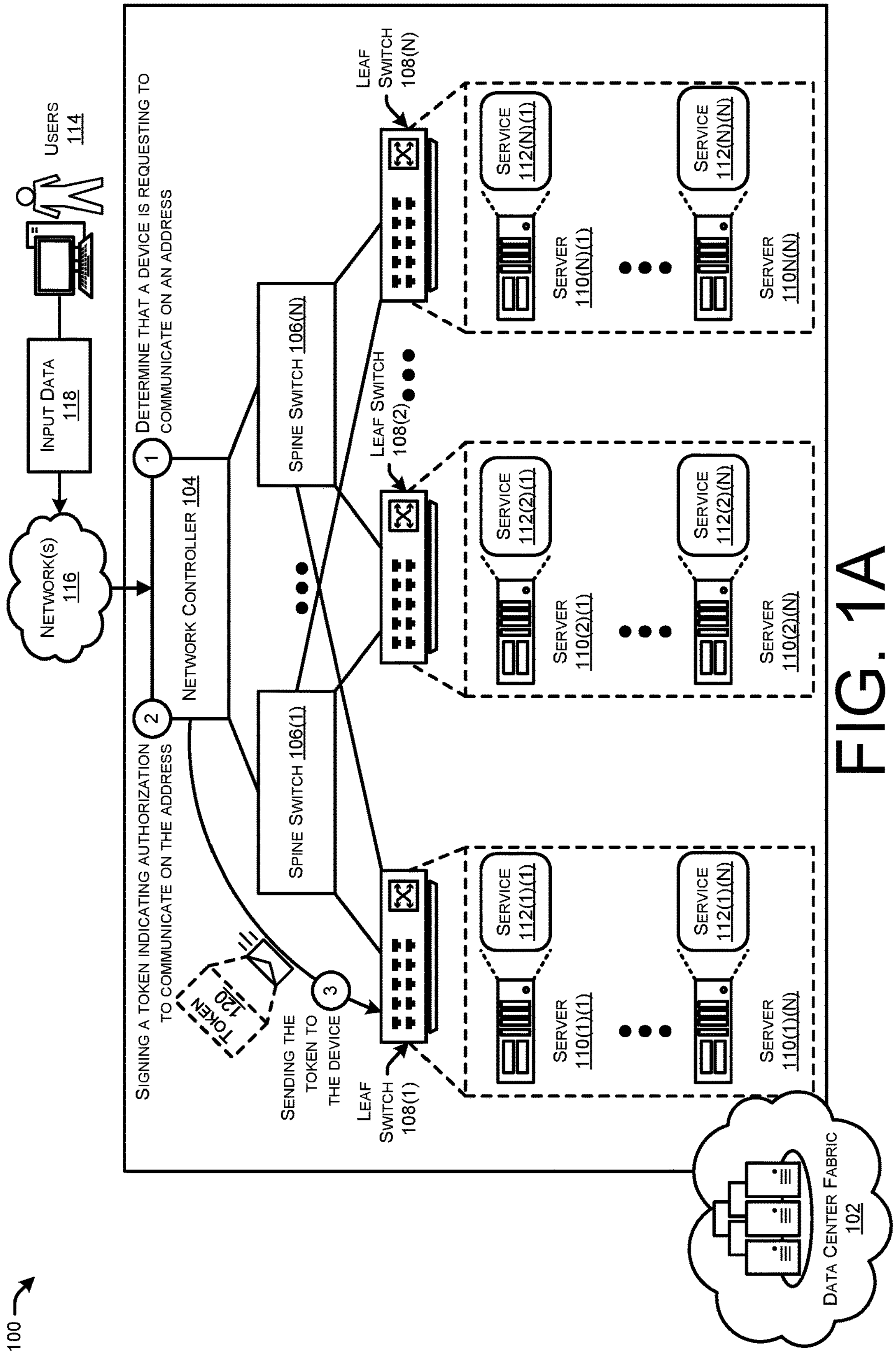
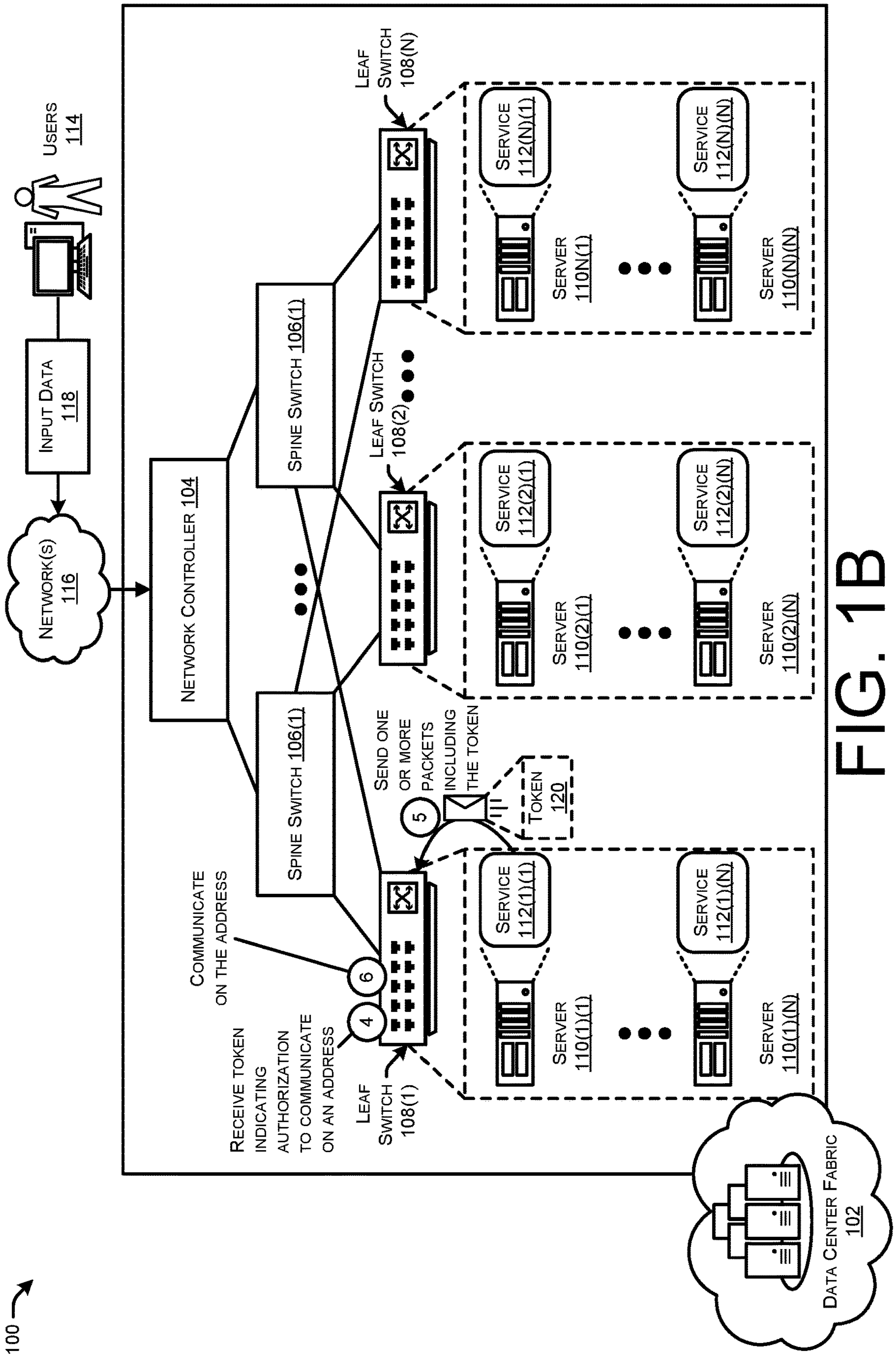

100
Users
114
Input Data
118
Network(s)
116
Network Controller 104
1
Determine that a device is requesting to communicate on an address
2
Signing a token indicating authorization to communicate on the address
3
Sending the token to the device
Token
120
Spine Switch 106(1)
Spine Switch 106(N)
Leaf Switch 108(1)
Leaf Switch 108(2)
Leaf Switch 108(N)
Service 112(1)(1)
Service 112(1)(N)
Service 112(2)(1)
Service 112(2)(N)
Service 112(N)(1)
Service 112(N)(N)
Server 110(1)(1)
Server 110(1)(N)
Server 110(2)(1)
Server 110(2)(N)
Server 110(N)(1)
Server 110N(N)
Data Center Fabric
102

FIG. 1A



100
Users 114
Input Data 118
Network(s) 116
Network Controller 104
Spine Switch 106(1)
Spine Switch 106(1)
Leaf Switch 108(1)
Leaf Switch 108(2)
Leaf Switch 108(N)
Receive token indicating authorization to communicate on an address
4
Communicate on the address
6
Send one or more packets including the token
5
Token 120
Service 112(1)(1)
Service 112(1)(N)
Service 112(2)(1)
Service 112(2)(N)
Service 112(N)(1)
Service 112(N)(N)
Server 110(1)(1)
Server 110(1)(N)
Server 110(2)(1)
Server 110(2)(N)
Server 110N(1)
Server 110(N)(N)
Data Center Fabric 102

FIG. 1B

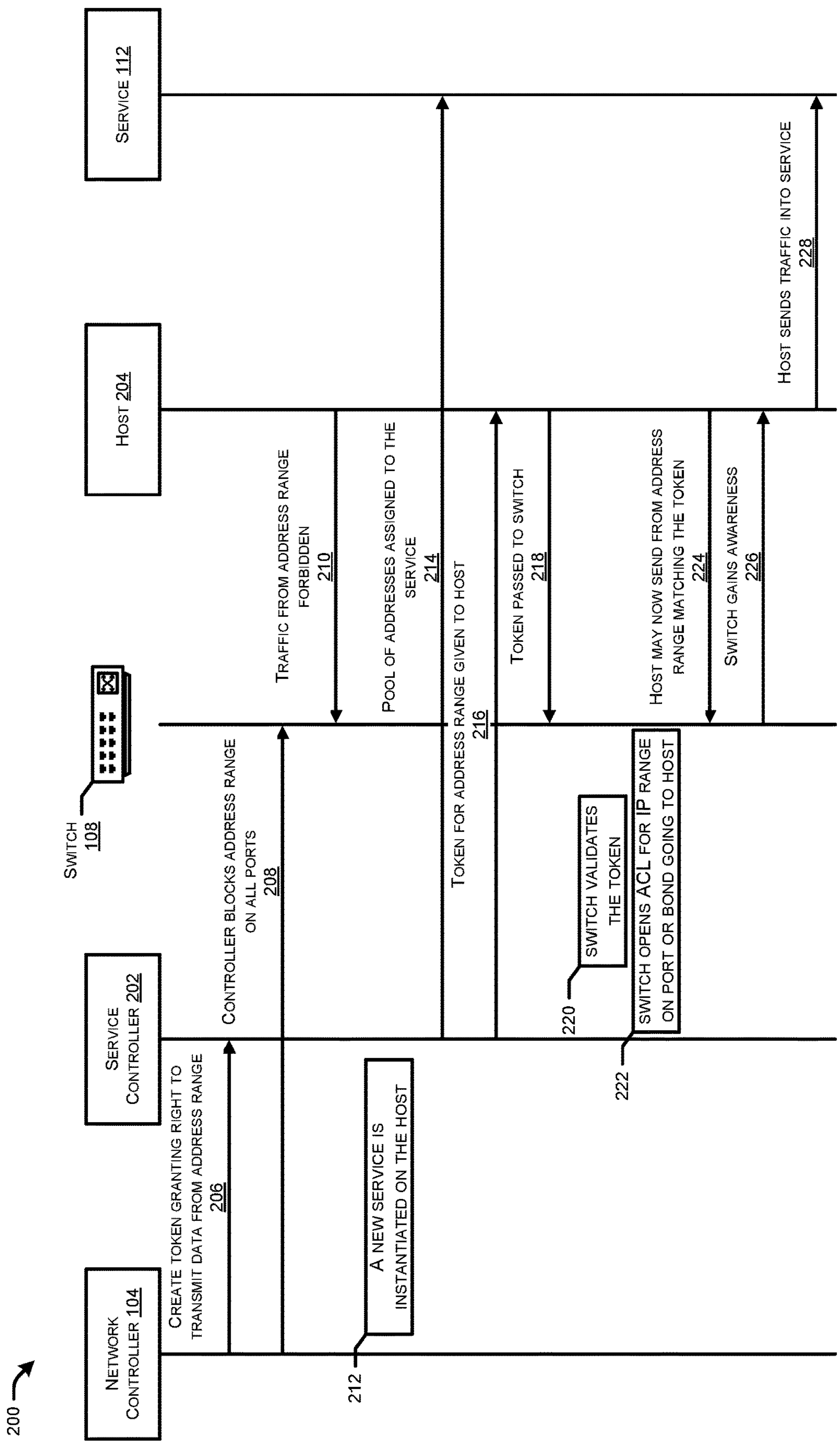

200
NETWORK CONTROLLER 104
SERVICE CONTROLLER 202
SWITCH 108
HOST 204
SERVICE 112
CREATE TOKEN GRANTING RIGHT TO TRANSMIT DATA FROM ADDRESS RANGE 206
CONTROLLER BLOCKS ADDRESS RANGE ON ALL PORTS 208
TRAFFIC FROM ADDRESS RANGE FORBIDDEN 210
212
A NEW SERVICE IS INSTANTIATED ON THE HOST
POOL OF ADDRESSES ASSIGNED TO THE SERVICE 214
TOKEN FOR ADDRESS RANGE GIVEN TO HOST 216
TOKEN PASSED TO SWITCH 218
220
SWITCH VALIDATES THE TOKEN
222
SWITCH OPENS ACL FOR IP RANGE ON PORT OR BOND GOING TO HOST
HOST MAY NOW SEND FROM ADDRESS RANGE MATCHING THE TOKEN 224
SWITCH GAINS AWARENESS 226
HOST SENDS TRAFFIC INTO SERVICE 228

FIG. 2

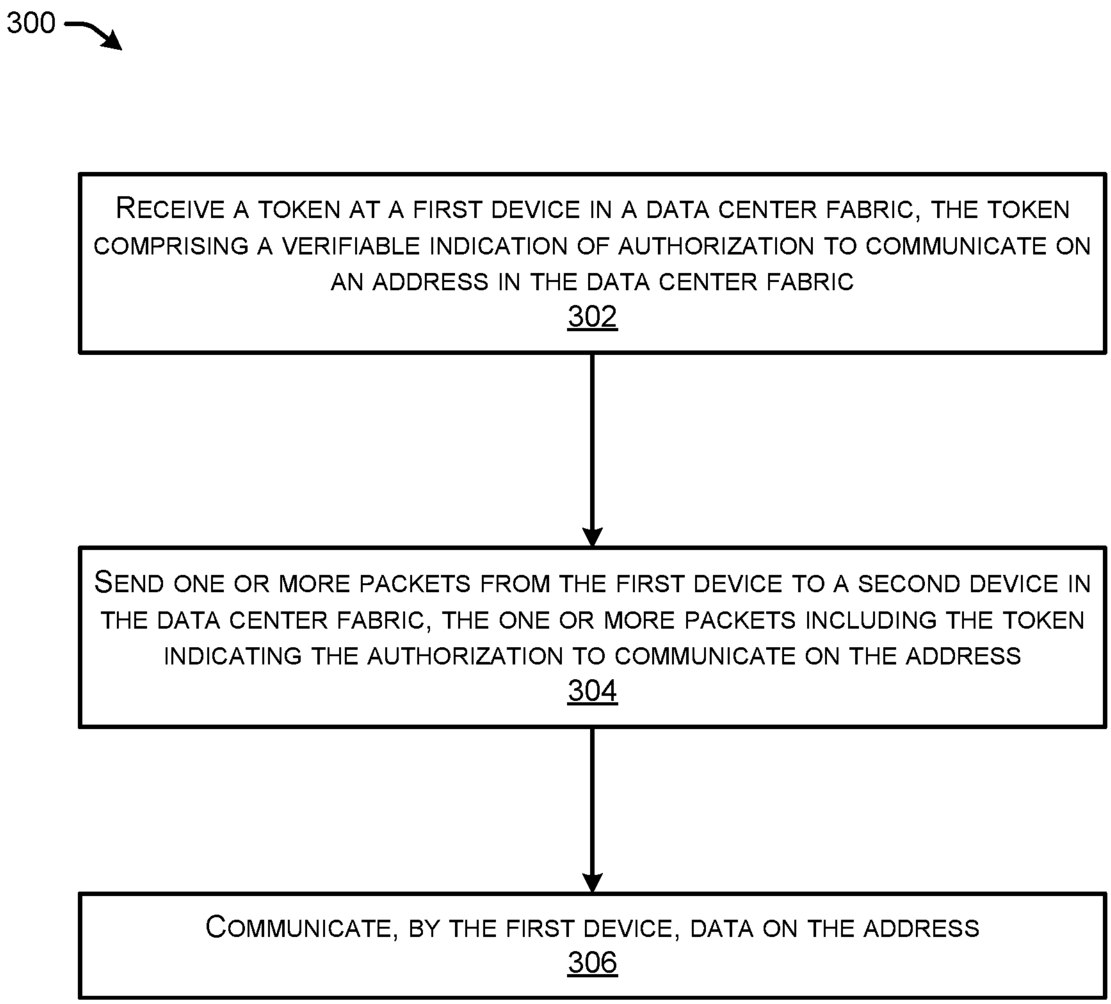

300
RECEIVE A TOKEN AT A FIRST DEVICE IN A DATA CENTER FABRIC, THE TOKEN COMPRISING A VERIFIABLE INDICATION OF AUTHORIZATION TO COMMUNICATE ON AN ADDRESS IN THE DATA CENTER FABRIC
302
SEND ONE OR MORE PACKETS FROM THE FIRST DEVICE TO A SECOND DEVICE IN THE DATA CENTER FABRIC, THE ONE OR MORE PACKETS INCLUDING THE TOKEN INDICATING THE AUTHORIZATION TO COMMUNICATE ON THE ADDRESS
304
COMMUNICATE, BY THE FIRST DEVICE, DATA ON THE ADDRESS
306

FIG. 3

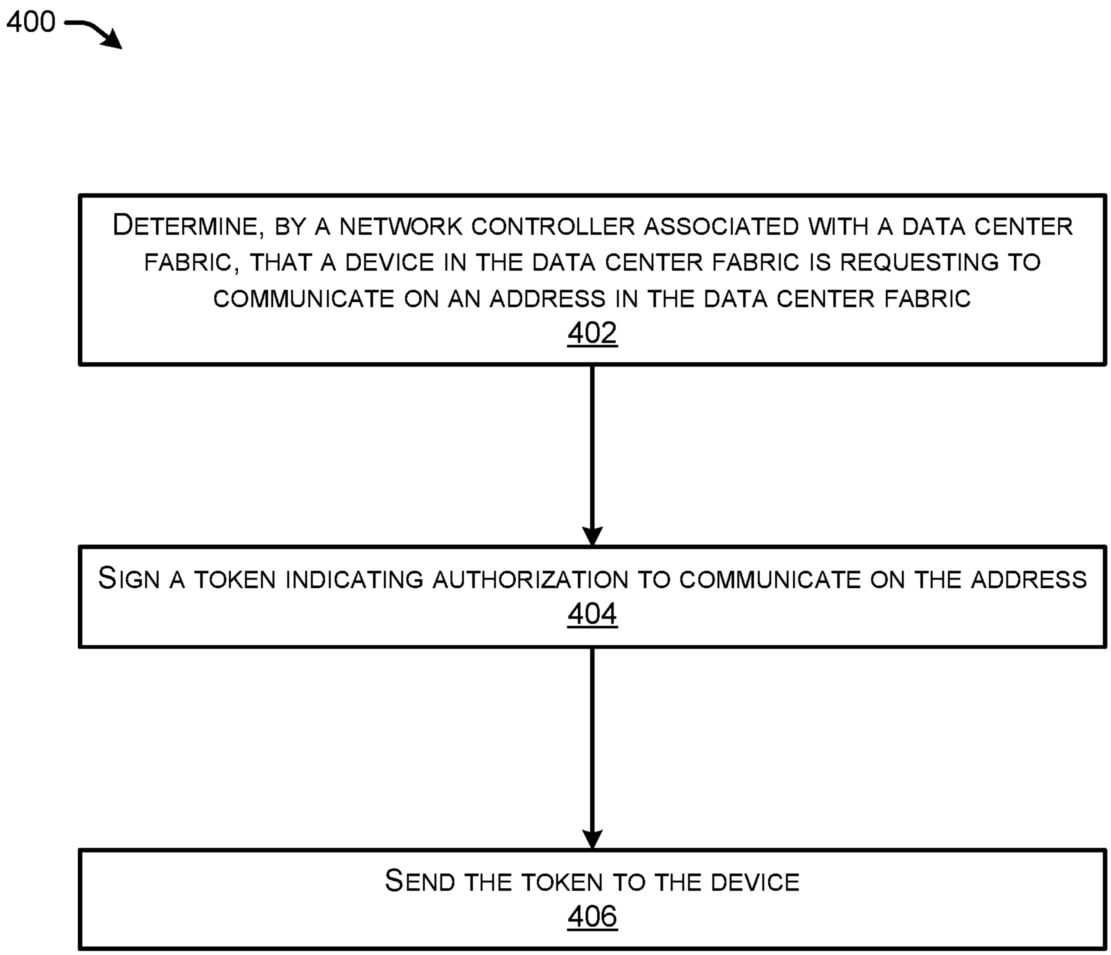

400
DETERMINE, BY A NETWORK CONTROLLER ASSOCIATED WITH A DATA CENTER FABRIC, THAT A DEVICE IN THE DATA CENTER FABRIC IS REQUESTING TO COMMUNICATE ON AN ADDRESS IN THE DATA CENTER FABRIC
402
SIGN A TOKEN INDICATING AUTHORIZATION TO COMMUNICATE ON THE ADDRESS
404
SEND THE TOKEN TO THE DEVICE
406

FIG. 4

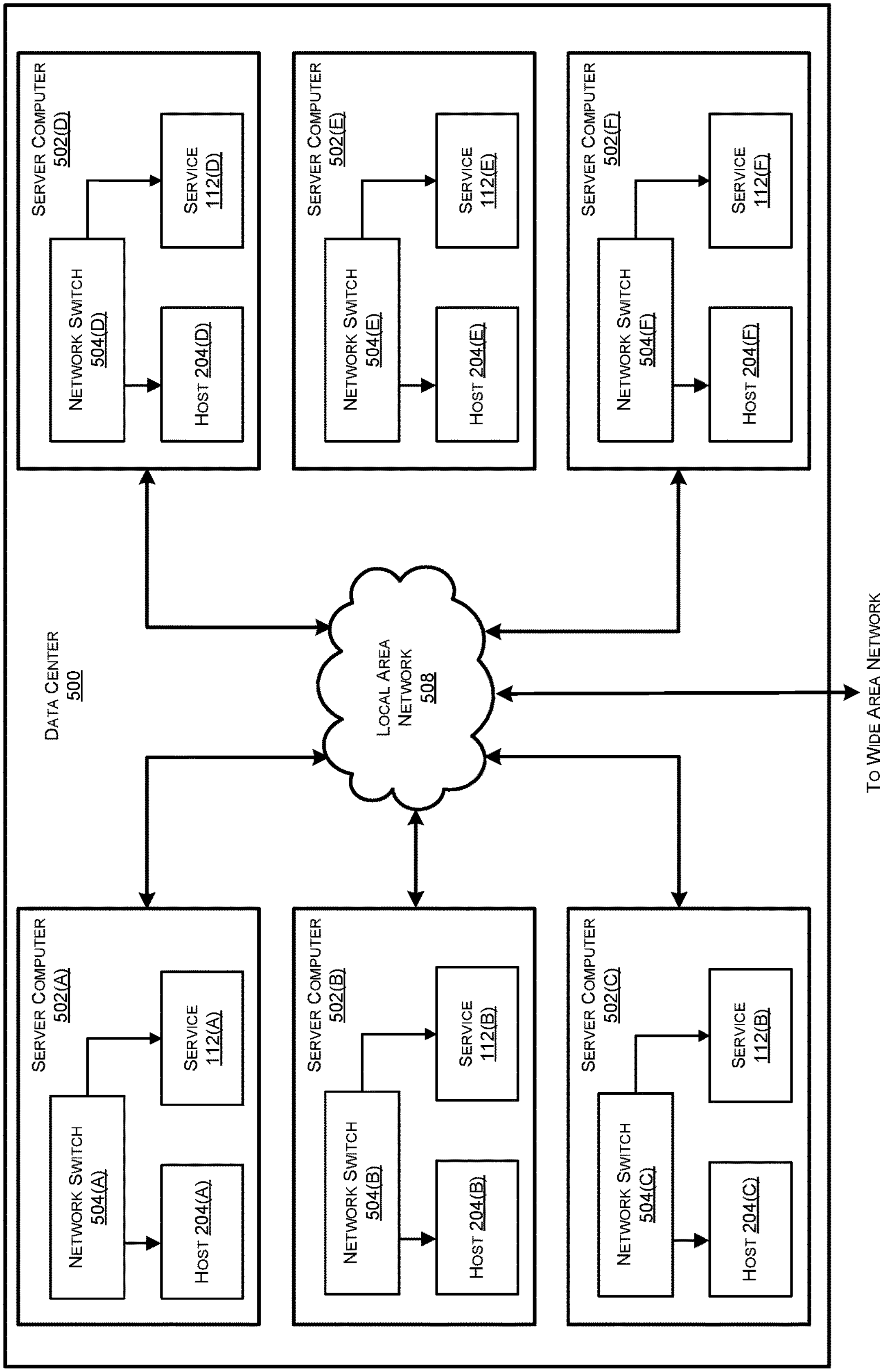
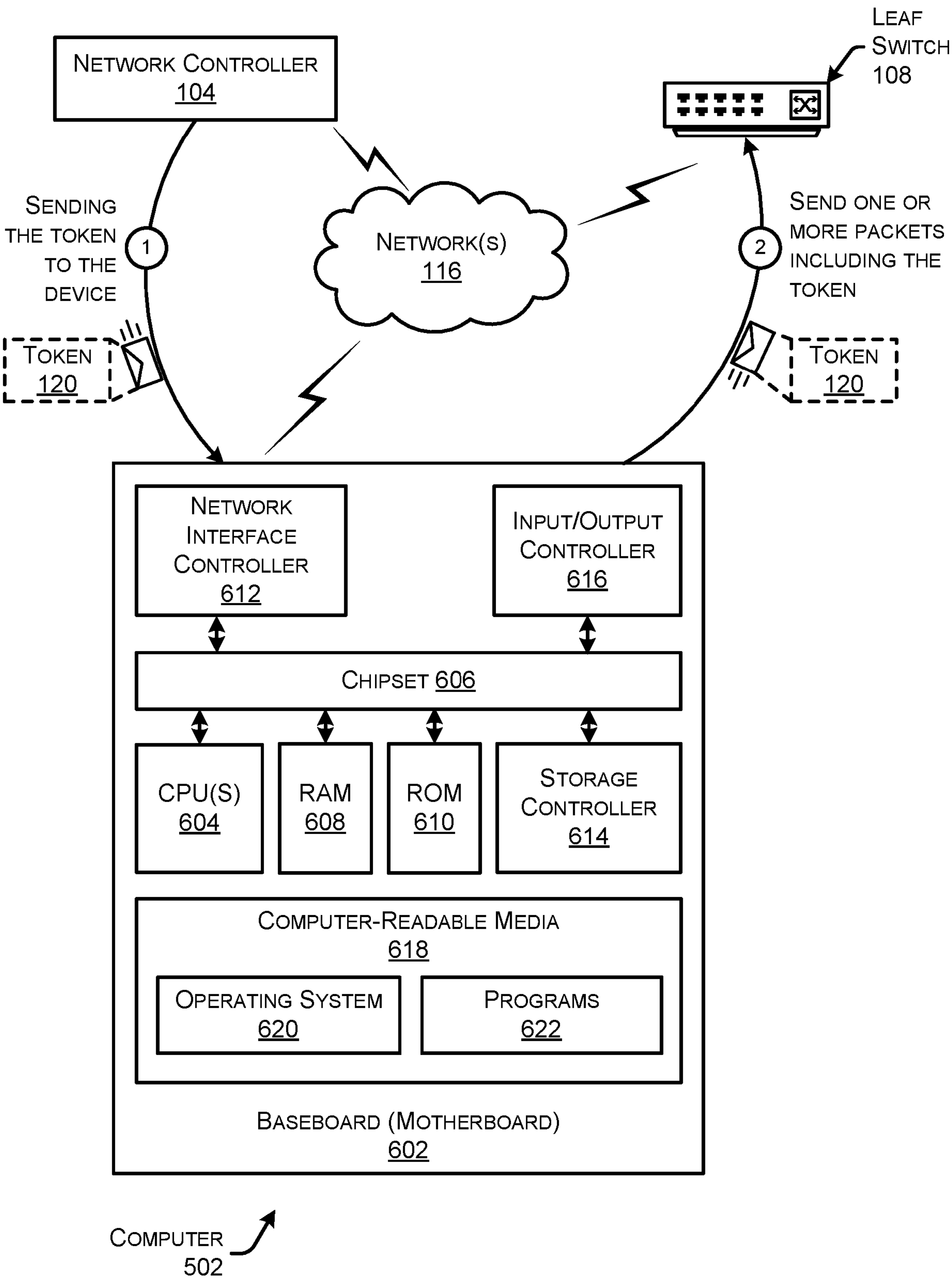

Data Center
500
Server Computer
502(D)
Network Switch
504(D)
Service
112(D)
Host 204(D)
Server Computer
502(E)
Network Switch
504(E)
Service
112(E)
Host 204(E)
Server Computer
502(F)
Network Switch
504(F)
Service
112(F)
Host 204(F)
Local Area
Network
508
To Wide Area Network
Server Computer
502(A)
Network Switch
504(A)
Service
112(A)
Host 204(A)
Server Computer
502(B)
Network Switch
504(B)
Service
112(B)
Host 204(B)
Server Computer
502(C)
Network Switch
504(C)
Service
112(B)
Host 204(C)

FIG. 5



NETWORK CONTROLLER 104
LEAF SWITCH 108
NETWORK(S) 116
SENDING THE TOKEN TO THE DEVICE
1
TOKEN 120
SEND ONE OR MORE PACKETS INCLUDING THE TOKEN
2
TOKEN 120
NETWORK INTERFACE CONTROLLER 612
INPUT/OUTPUT CONTROLLER 616
CHIPSET 606
CPU(S) 604
RAM 608
ROM 610
STORAGE CONTROLLER 614
COMPUTER-READABLE MEDIA 618
OPERATING SYSTEM 620
PROGRAMS 622
BASEBOARD (MOTHERBOARD) 602
COMPUTER 502

FIG. 6

TRANSFERRING VERIFIABLE ADDRESS RIGHTS BETWEEN DEVICES OF A DATA CENTER (DC) NETWORK

TECHNICAL FIELD

The present disclosure relates generally to transferring address rights (e.g., internet protocol address(es), media access control address(es), etc.) amongst devices in a data center network fabric.

BACKGROUND

Service providers offer computing-based services, or solutions, to provide users with access to computing resources to fulfill users' computing resource needs without having to invent in and maintain computing infrastructure required to implement the services. These service providers often maintain networks of data centers which house servers, routers, and other devices that provide computing resources to users such as compute resources, networking resources, storage resources, database resources, application resources, security resources, and so forth. Users may be allocated portions of the computing resources using virtualization technology that remain available for peak demands of the users. The virtualized portions, or virtualized networks, of computing resources may be scaled up (or down) according to the computing needs of a given user without the need to maintain excess computing capacity.

To support a service (or application) using cloud computing, various types of schedulers are utilized to automate deployment, scaling, and operations of the virtual computing resources (or "virtual resources") across physical servers in a cloud computing network. To effectively orchestrate the virtual resources, the schedulers may track what virtual resources have been placed on what physical servers in order to determine where to spin up or migrate virtual resources. For example, a scheduler may determine that the resource utilization of a physical server has increased, and the physical server may be unable to support one or more virtual resources deployed to the physical server. The scheduler may then identify an additional physical server that has availability of server resources to adequately support the virtual resource. The virtual resource may then be migrated and deployed to the other physical server that has availability to support the virtual resource. However, migration of a virtual resource from one physical server to another may lead to difficulties routing communications between virtual resources executing on separate physical servers.

To effectively manage migration of virtual resources across a number of physical servers, a switch may be utilized to forward packets to virtual services that are deployed on the physical servers. When a virtual resource is migrated from a source server to destination server, the virtual resource may begin sending data from a new address, and a respective switch may transmit an advertisement message to various switches in a data center fabric alerting each of such a migration. While advertising the migration is advantageous for various reasons, there is no validation of the addresses that are exchanged between hosts, resources, and/or devices.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is set forth below with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different figures indicates similar or identical items. The systems depicted in the accompanying figures are not to scale and components within the figures may be depicted not to scale with each other.

FIG. **1**A illustrates a system-architecture diagram of an example flow for transferring address rights (e.g., internet protocol address(es), media access control address(es), etc.) amongst devices in a data center network fabric. A network controller of the data center fabric may determine that a device is requesting to communicate on an address in the network, sign a token indicating authorization to communicate on the address, and send the token to the device.

FIG. **1**B illustrates a system-architecture diagram of an example flow for transferring address rights (e.g., internet protocol address(es), media access control address(es), etc.) amongst devices in a data center network fabric. A device (e.g., a switch) of a data center fabric may receive a token indicating authorization to communicate on an address in the network, send one or more packets including the token to a second device in the data center fabric, and may communicate on the address.

FIG. **2** illustrates a data flow diagram of an example process according to which address rights (e.g., internet protocol address(es), media access control address(es), etc.) may be transferred between devices in a data center network fabric.

FIG. **3** illustrates a flow diagram of an example method for a first device in a data center fabric to receive a token comprising a verifiable indication of authorization to communicate on an address in the fabric, send one or more packets comprising the token to a second device in the data center fabric, and communicate on the address.

FIG. **4** illustrates a flow diagram of an example method for a network controller associated with a data center fabric to determine that a device in the data center fabric is requesting to communicate on an address, sign a token indicating authorization to communicate on the address, and send the token to the device.

FIG. **5** illustrates a computing system diagram illustrating a configuration for a data center that can be utilized to implement aspects of the technologies disclosed herein.

FIG. **6** is a computer architecture diagram showing an illustrative computer hardware architecture for implementing a server device that can be utilized to implement aspects of the various technologies presented herein.

DESCRIPTION OF EXAMPLE EMBODIMENTS

Overview

This disclosure describes a method for a network controller (or a service controller) associated with a data center fabric network to determine that a device in the data center fabric is requesting to communicate on an address, sign a token indicating authorization to communicate on the address, and send the token to the device allowing the device to communicate on the address in the data center fabric using the signed token. The method includes determining, by a network controller associated with a data center fabric, that a device in the data center fabric is requesting to communicate on an address in the data center fabric. Additionally, or alternatively, the method includes signing a token indicating authorization to communicate on the address. Additionally, or alternatively, the method includes sending the token to the device.

Additionally, or alternatively, the method includes receiving a token at a first device in a data center fabric, the token comprising a verifiable indication of authorization to communicate on an address in the data center fabric. Additionally, or alternatively the method includes sending one or more packets from the first device to a second device in the data center fabric, the one or more packets including the token indicating the authorization to communicate on the address. Additionally, or alternatively, the method includes communicating, by the first device, data on the address.

Additionally, the techniques described herein may be performed by a system and/or device having non-transitory computer-readable media storing computer-executable instructions that, when executed by one or more processors, performs the method described above.

Example Embodiments

The usefulness of virtual resources offered by data centers has resulted in a rapid increase in cloud computing offering a wide range of services that may be fined-tuned to meet a user's needs. For example, a scheduler may determine that the resource utilization of a physical server has increased, and the physical server may be unable to support one or more virtual resources deployed to the physical server. The scheduler may then identify an additional physical server that has availability of server resources to adequately support the virtual resource. The virtual resource may then be migrated and deployed to the other physical server that has availability to support the virtual resource. However, migration of a virtual resource from one physical server to another may lead to difficulties routing communications between virtual resources executing on separate physical servers. To effectively manage migration of virtual resources across a number of physical servers in a data center fabric network, a switch may be utilized to forward packets to virtual services that are deployed on the physical servers. When a virtual resource is migrated from a source server to destination server, the virtual resource may begin sending data from a new address, and a respective switch may transmit an advertisement message to various switches in a data center fabric alerting each of such a migration. While advertising the migration is advantageous for various reasons, there is no validation of the addresses that are exchanged between hosts, resources, and/or devices.

Additionally, when the addresses a server is running are known, access control lists (ACLs) and/or policies may be applied in the fabric to ensure that that server, and only that server, can send data using the address. This is useful from a security perspective and in preventing software managing teams from affecting each other through destructive accidental events, e.g., spoofing. However, applying these ACLs and/or policies may be difficult with the movement of addresses about the data center network fabric.

This disclosure describes techniques to generate and transfer verifiable address rights (e.g., internet protocol (IP) address(es), media access control (MAC) address(es), etc.) amongst devices in a data center network fabric. For example, in a data center network fabric, a server may have one IP and/or MAC address (e.g., if the server is running an operating system) or the server may have a fixed and known set of IP and/or MAC addresses (e.g., if the server is executing virtual machine(s) (VM)). A host, executing on a server and/or supporting a service, may begin to utilize a new IP and/or MAC address for various reasons, such as, for example, a new VM boots up, the server is running a portion of a service chain and routing packets, or a VM has migrated. In some examples, a device and/or service in the data center network fabric may generate and/or issue a token that represents the right to send data from a specific IP and/or MAC address. For example, when a new service and/or VM starts up, a node (e.g., a switch) delegated to a server in which the service and/or VM is operating, may receive a token comprising a verifiable indication of authorization to communicate on an address in the data center fabric. The switch may then send one or more packets, including the token, to a second device in the data center fabric (e.g., another switch). Then, the switch may then begin to communicate data on the address on behalf of the service and/or VM. Additionally, or alternatively, a device and/or service in the data center network fabric, such as, for example, a network controller and/or a service controller, may determine that a device in the data center fabric is requesting to communicate on an address in the data center network fabric. The network controller, service controller, and/or any other network device in the fabric may then generate and/or sign a token indicating authorization to communicate on the address. In some examples, the token may be signed by a private key of the possessing device and/or component. The network controller and/or service controller may then send the token to the device requesting to communicate on the address.

Take, for example, a VM or a service starting up on a first server in a data center (DC) network fabric. A DC authority (e.g., a network controller) may receive an indication of such a startup from a first switch associated with the first server on which the service is operating. Additionally, or alternatively, the first switch may send a request to the DC authority to communicate on an IP address (or an IP address range) in the DC network fabric. Additionally, or alternatively, the switch may send the request to the DC authority to communicate on a specific MAC address in the DC network fabric. As such, the DC authority may determine that the first switch is requesting to communicate on the address in the DC network fabric. In some examples, the address may be configured as an IP address. Additionally, or alternatively, the address may be configured as a MAC address.

The DC authority may then create a token indicating that any switch in possession of this token has the right to transmit packets from the IP address. In some examples, the DC authority may then sign the token indicating the authorization to communicate on the address. Additionally, or alternatively, the DC authority may send the token to a service controller associated with the DC network fabric. Additionally, or alternatively, the DC authority may be configured to store and/or manage the tokens without the assistance of a separate service controller.

Next, the DC authority may cause the first switch to block the IP address range on all of the associated ports. In some examples, the DC authority may cause the first switch to block the address range on all of the ports prior to the service starting up on the first server. At this point, traffic from the host (e.g., the first server) on this IP address range may be forbidden.

Once the service starts up, a pool of IP addresses may be assigned to the service. In some examples, the DC authority may assign the pool of IP addresses to the service. Additionally, or alternatively, the service controller may assign the pool of IP addresses to the service. From here, the token for the address range may be passed from the DC authority and/or the service controller over the link that is configured to host the IP address.

The host may then pass the token to the first switch, the DC authority, and/or the service controller, where the first switch (or the DC authority or the service controller) may validate the token. In some examples, the first switch may validate the token using various validation techniques, such as, for example, a crypto signature check and/or a validation of a reference against a database entry, or the like.

The first switch may then be configured to open the access control lists (ACLs) for the IP range on the port and/or the bond going to the host to permit data being sent from the IP address. Additionally, or alternatively, the first switch may inform other devices in the DC network fabric (e.g., additional switches) that other uses of the token, and therefore the IP address, have been revoked. In some examples, the first switch may be configured to inform the other devices directly. Additionally, or alternatively, the first switch may be configured to inform the other devices by employing the assistance of the DC authority.

At this point, the host may now send from the address range matching the token. As such, incoming traffic to an address in the address range is received at the host, as the first switch is aware that the host has this address range and has the authorized validation to communicate on the address range. The host may then send the traffic into the service.

The tokens described herein may be configured such that they may only be active in one location (e.g., one switch) at a time. Additionally, or alternatively, the tokens may be configured such that they may be active in several locations, such as, for example, in equal-cost multi-path routing (ECMP) implementations, where the address is in several locations simultaneously.

Additionally, or alternatively, the service may migrate from the first server in the DC network fabric to a second server in the DC network fabric. In some examples, a second switch associated with the second server may send a request for the token to the first switch. In such examples, the first switch may perform a token delegation to the second switch. The first switch may perform the token delegation in various ways, such as, for example, a transfer of some or all rights associated with the token or a duplication of some or all rights associated with the token and subsequent transfer of the duplicated rights. In some examples, the token delegation may be configured as a simple transfer of the data (e.g., the token) from the first switch to the second switch, and the token may be configured such that whoever has a copy can utilize it. Additionally, or alternatively, the token delegation may be configured as a cryptographic operation where information may be added and/or replaced in the token, while the token remains covered by a signature indicating the validity of the token. In any of the examples previously described, the token delegation procedure may be performed utilizing the DC authority (e.g., the DC authority may reissue the token to a desired location and/or revoke a token from a previous location) and/or may be performed by asking the locally connected device (e.g., the first switch) to reissue the token and specifying any additional information to include in the token. Additionally, or alternatively, such token delegation methods may include explicit token revocation instructions, such that, when the token is utilized (e.g., transmitted with a packet), the DC authority may revoke any rights associated with the token on the previous host and/or at any other host included in the DC network fabric.

As described herein, a computing-based and/or cloud-based solution and/or service can generally include any type of resources implemented by virtualization techniques, such as containers, virtual machines, virtual storage, and so forth. Further, although the techniques described as being implemented in data center fabrics and/or a cloud computing network, the techniques are generally applicable for any network of devices managed by any entity where virtual resources are provisioned. In some instances, the techniques may be performed by a schedulers or orchestrator, and in other examples, various components may be used in a system to perform the techniques described herein. The devices and components by which the techniques are performed herein are a matter of implementation, and the techniques described are not limited to any specific architecture or implementation.

The techniques described herein provide various improvements and efficiencies with respect to transferring addresses (e.g., IP address, MAC address, etc.) amongst hosts, services, and/or devices in a data center network fabric. For instance, the techniques described herein create and sign a token that indicates validated rights to send from a specified address. By encapsulating the validated rights to send from the specified address in the token, the rights can be delegated from one machine to another in a data center network fabric, allowing for a data center authority to apply address restrictions automatically to new services that spin up in the data center network fabric, resulting in an increased scalability. Additionally, or alternatively, by encapsulating the validated rights in the token, the rights can be seamlessly delegated from one device to another following migration of a service from one location to another.

Certain implementations and embodiments of the disclosure will now be described more fully below with reference to the accompanying figures, in which various aspects are shown. However, the various aspects may be implemented in many different forms and should not be construed as limited to the implementations set forth herein. The disclosure encompasses variations of the embodiments, as described herein. Like numbers refer to like elements throughout.

FIG. **1**A illustrates a system-architecture diagram of an example flow **100** for transferring address rights (e.g., internet protocol address(es), media access control address(es), etc.) amongst devices in a data center network fabric **102**. A network controller **104** of the data center fabric **102** may determine that a device is requesting to communicate on an address in the network **102**, sign a token indicating authorization to communicate on the address, and send the token to the device.

The data center fabric **102** may comprise one or more data centers that include various networking devices, such as, spine network switches **106**A-N, leaf network switch(es) **108**(**1**)-(N), and physical servers **110**(**1**)(**1**)-(N)(N), where N is any integer greater than "1." In some examples, the data center(s) may be located across geographic areas, and the data center fabric **102** may be a distributed network through which users (often customers) may interact via user devices to manage or otherwise interact with service provided by the data center network fabric **102**.

The data center network fabric **102** may provide on-demand availability of computing system resources of physical server(s) **110**, such as data storage, computing power (e.g., CPU, GPU, etc.), networking, databases, etc., without direct active management by users. In some examples, the data center network fabric **102** may be managed and maintained by a service provider such that users do not have to invest in and maintain the computing infrastructure for their computing resource needs. Generally, a user may be provided access to, or allocated use of, a portion of the computing resources of physical server(s) **110** in the data center network fabric **102**. The data center network fabric **102** may scale, such as by spinning up resources or spinning down resources, based on demand for the individual users. The portions of the data center network fabric **102** may be allocated using hardware virtualization such that portions of the data center network fabric **102** can be configured and managed by the user (e.g., security configuration, load balancing configuration, etc.). However, the data center network fabric **102** need not be managed by a service provider, and can be managed by any entity, including the user themselves that run the applications or services.

In some examples, physical server(s) **110** may host one or more virtual machines. Each virtual machine may be configured to execute one of various operations and act as one or more virtual components for the cloud computing network **102**, such as, for example, a service **112**(**1**)(**1**)-(N)(N) where N is any integer greater than "1." In some examples, the physical server(s) **110** may host any number of virtual machines.

Generally, the number of services **112** may scale based on a number of users **114** interacting with the cloud computing network. The users **114** may comprise one or more of individual users, groups of users, organizations, businesses, or other entities that interact with the data center network fabric **102** via respective user devices. The user devices may be any type of computing device capable of connecting to the data center network fabric **102** via a suitable data communications network **116** such as, but not limited to, a laptop or desktop computer, a tablet computing device, a server computer, a television, or a mobile telephone. Administrative users employed by the operator of the data center network fabric **102**, such as administrators managing the operation of the data center network fabric **102**, might also connect with, manage, and utilize resources provided by the data center network fabric **102** in a similar fashion.

The users **114** may provide input data **118** via the network(s) **116** to interact with the service **112** that is supported by the virtual machines running on the servers **110**. For example, the users **114** may submit requests to process data, retrieve data, store data, and so forth such that virtual machines hosting the services **112** are spun up or spun down to process the requests based on demand.

In some examples, the data center network fabric **102** may generate and transfer verifiable address rights (e.g., internet protocol (IP) address(es), media access control (MAC) address(es), etc.) amongst devices in the data center network fabric **102**. For example, in a data center network fabric **102**, a server **110** may have one IP and/or MAC address (e.g., if the server is running an operating system) or the server **110** may have a fixed and known set of IP and/or MAC addresses (e.g., if the server is executing virtual machine(s) (VM)). A host, executing on a server **110** and/or supporting a service **112**, may begin to utilize a new IP and/or MAC address for various reasons, such as, for example, anew VM boots up, the server **110** is running a portion of a service chain and routing packets, or a VM has migrated.

In some examples, a device **110**, component (e.g., the network controller **104**), and/or service **112** in the data center network fabric **102** may generate and/or issue a token **120** that represents the right to send data from a specific IP and/or MAC address. For example, when a new service **110** and/or VM starts up, a node (e.g., a switch **108**) delegated to a server **110** in which the service **112** and/or VM is operating, may receive a token **120** comprising a verifiable indication of authorization to communicate on an address in the data center fabric **102**. The switch **108** may then send one or more packets, including the token, to a second device (e.g., another switch **108** and/or server **110**) in the data center fabric **102**. Then, the switch **108** may then begin to communicate data on the address on behalf of the service **112** and/or VM. Additionally, or alternatively, a device and/or service in the data center network fabric **102**, such as, for example, a network controller **104** and/or a service controller, may determine that a device in the data center fabric **102** is requesting to communicate on an address in the data center network fabric **102**. The network controller **104** and/or service controller may then generate and/or sign a token **120** indicating authorization to communicate on the address. The network controller **104** and/or service controller may then send the token **120** to the device requesting to communicate on the address.

Take, for example, a VM or a service **112**(**1**)(**1**) starting up on a first server **110**(**1**)(**1**) in a data center (DC) network fabric **102**. A DC authority (e.g., a network controller **104**) may receive an indication of such a startup from a first switch **108**A associated with the first server **110**(**1**)(**1**) on which the service **112**(**1**)(**1**) is operating. Additionally, or alternatively, the first switch **108**(**1**) may send a request to the DC authority **104** to communicate on an IP address (or an IP address range) in the DC network fabric **102**. Additionally, or alternatively, the first switch **108**(**1**) may send the request to the DC authority **104** to communicate on a specific MAC address in the DC network fabric **102**.

The tokens **120** described herein may be configured such that they may only be active in one location (e.g., one switch) at a time. Additionally, or alternatively, the tokens **120** may be configured such that they may be active in several locations, such as, for example, in equal-cost multi-path routing (ECMP) implementations, where the address is in several locations simultaneously.

At "**1**," the DC authority **104** may determine that the first switch **108**(**1**) is requesting to communicate on the address in the DC network fabric **102**. In some examples, the address may be configured as an IP address. Additionally, or alternatively, the address may be configured as a MAC address. As such, it should be appreciated that any of the process(es) described herein may be performed with respect to an IP address and/or a MAC address of a device **110** and/or service **112** in the data center network fabric **102**.

In some examples, at "**2**," the DC authority **104** may then create a token **120** indicating that any switch **106**, **108** in possession of this token has the right to transmit packets from the IP address. In some examples, the DC authority **104** may then sign the token **120** indicating the authorization to communicate on the address. In some examples, the DC authority **104** may sign, or otherwise verify and/or authorize the token **120** using a private key and/or public key value. the DC authority may send the token to a service controller associated with the DC network fabric. Additionally, or alternatively, the DC authority may be configured to store and/or manage the tokens without the assistance of a separate service controller.

At "**3**," the DC authority may send the token **120** to the first switch **108**(**1**) which is configured to route data to and from the servers **110**(**1**)(**1**)-**110**(**1**)(N) and/or the services **112**(**1**)(**1**)-**112**(**1**)(N). For example, the DC authority **104** may send the token **120** to the first switch **108**(**1**) configured to transmit data including the service **112**(**1**)(**1**) executing on the server **110**(**1**)(**1**).

In some examples, the example flow may continue from step "**3**" of FIG. **1**A to step "**4**" of FIG. **1**B. Additionally, or alternatively, the example flow may begin from step "**4**" of FIG. **1**B and continue from step "**6**" of FIG. **1**B to step "**1**" of FIG. **1**A. Additionally, or alternatively, the example flow from FIG. **1**A may be executed simultaneously with the example flow of FIG. **1**B.

FIG. **1**B illustrates a system-architecture diagram of an example flow for transferring address rights (e.g., internet protocol address(es), media access control address(es), etc.) amongst devices in a data center network fabric **102**. A device (e.g., a switch **108**) of a data center fabric **102** may receive a token indicating authorization to communicate on an address in the network, send one or more packets including the token **120** to a second device in the data center fabric **102**, and may communicate on the address.

At "**4**," the first switch **108**(**1**) may receive the token **120** from the DC authority **104**. Additionally, or alternatively, the first switch **108**(**1**) may receive the token **120** from one or more additional switch(es) **108**(**1**)-**108**(N) included in the data center fabric **102**. In some examples, the token **120** may comprise an indication of an address, such as, for example, a MAC address and/or an IP address, and/or a verifiable authorization to communicate on the address. As previously mentioned, the token **120** may be signed by a public key and/or private key of the DC authority **104** and/or the switch **108** from which the token was received. In some examples, the first switch **108**(**1**) may pass along the token **120** to the service **112**(**1**)(**1**) and/or the first server **110**(**1**)(**1**) supporting the service **112**(**1**)(**1**). Additionally, or alternatively, the DC authority **104** may transmit the token **120** directly to the service **112**(**1**)(**1**) and/or the first server **110**(**1**)(**1**) supporting the service **112**A(**1**).

At "**5**," the first server **110**(**1**)(**1**) and/or the service **112**(**1**)(**1**) may send one or more packets to the first switch **108**(**1**). In some examples, the one or more packets may include the token **120**. The first switch **108**(**1**) may receive the token **120** and validate the token **120**, that is, the first switch **108**(**1**) may decrypt the token **120** using a public key of the network controller **104** and/or the switch **108** from which the token **120** was received.

At "**6**," the service **112**(**1**)(**1**), the first server **110**(**1**)(**1**), and/or the first switch **108**(**1**) may be configured to communicate on the address. That is, the service **112**(**1**)(**1**), the first server **110**(**1**)(**1**), and/or the first switch **108**(**1**) may be configured to transmit data to and from an additional service **112**, an additional server **110**, and/or an additional switch **108** such that the address indicated by the token supports the communication. In some examples, the first switch **108**(**1**) may open the access control list (ACL) for the address range indicated by the token **120**.

Additionally, or alternatively, the service **112**(**1**)(**1**) may migrate from the first server **110**(**1**)(**1**) in the DC network fabric **102** to a second server **110**(**2**)(**1**) in the DC network fabric **102**. In some examples, a second switch **108**(**2**) associated with the second server **110**(**2**)(**1**) may send a request for the token **120** to the first switch **108**(**1**). In such examples, the first switch **108**(**1**) and/or the first server **110**(**1**)(**1**) may perform a token delegation to the second switch **108**(**2**) and/or the second server **110**(**2**)(**1**). The first switch **108**(**1**) may perform the token delegation in various ways, such as, for example, a transfer of some or all rights associated with the token **120** or a duplication of some or all rights associated with the token **120** and subsequent transfer of the duplicated rights.

In some examples, the token delegation may be configured as a simple transfer of the data (e.g., the token **120**) from the first switch **108**(**1**) to the second switch **108**(**2**), and the token **120** may be configured such that whatever device has a copy can utilize it. Additionally, or alternatively, the token delegation may be configured as a cryptographic operation where information may be added and/or replaced in the token **120**, while the token remains covered by a signature indicating the validity of the token, such as, for example, a signature using the private key of the device from which the token **120** is migrating from (e.g., the first switch **108**(A) and/or the first server **110**(**1**)(**1**). In any of the examples previously described, the token delegation procedure may be performed utilizing the DC authority **104** (e.g., the DC authority **104** may reissue the token **120** to a desired location and/or revoke a token **120** from a previous location) and/or may be performed by asking the locally connected device (e.g., the first switch **108**(**1**)) to reissue the token **120** and specifying any additional information to include in the token **120**. Additionally, or alternatively, such token delegation methods may include explicit token revocation instructions, such that, when the token **120** is utilized (e.g., transmitted with a packet), the DC authority **104** may revoke any rights associated with the token **120** on the previous host and/or at any other host included in the DC network fabric **102**.

FIG. **2** illustrates a data flow diagram of an example process **200** according to which address rights (e.g., internet protocol address(es), media access control address(es), etc.) may be transferred between devices in a data center network fabric **102**. As previously mentioned, the data center network fabric **102** may include a network controller **104**, one or more switch(es) **106**, **108**, one or more physical servers **110** supporting one or more virtual services **112**, a service controller **202**, and/or one or more host(s) **204**.

At **206**, the process **200** may include creating a token indicating that any switch in possession of this token has the right to transmit packets from the IP address. In some examples, the DC authority **104** and/or the service controller **202** may create the token. In some examples, the DC authority **104** and/or the service controller **202** may then sign the token indicating the authorization to communicate on the address. Additionally, or alternatively, the DC authority **104** may send the token to a service controller **202** associated with the DC network fabric **102**. Additionally, or alternatively, the DC authority **104** may be configured to store and/or manage the tokens without the assistance of a separate service controller **202**.

At **208**, the DC authority may cause the first switch to block the IP address range on all of the associated ports. In some examples, the DC authority **104** may cause a first switch to block the address range on all of the ports prior to a service starting up on a first server, while a service starts up on a first server, and/or after the service has started up on a first server. At **210**, traffic from the host **204** (e.g., the first server) on this IP address range may be forbidden.

At **212**, a new service may be instantiated on the host **204**. In some examples, the service may be configured as any one of the service(s) **112** described with respect to FIGS. **1**A and **1**B. The DC authority **104** and/or the service controller **202** may be notified that such a service has been instantiated.

At **214**, a pool of IP addresses may be assigned to the service. In some examples, the DC authority **104** may assign the pool of IP addresses to the service. Additionally, or alternatively, the service controller **202** may assign the pool of IP addresses to the service. At **216**, the token for the address range may be passed from the DC authority **104** and/or the service controller **202** over the link that is configured to host the IP address.

At **218**, the host **204** may then pass the token to the first switch, the DC authority **104**, and/or the service controller **202**, where the first switch (or the DC authority or the service controller) may validate the token. At **220**, the first switch may validate the token using various validation techniques, such as, for example, a crypto signature check and/or a validation of a reference against a database entry, or the like.

At **222**, the first switch may then be configured to open the access control lists (ACLs) for the IP range on the port and/or the bond going to the host **204** to permit data being sent from the IP address. Additionally, or alternatively, the first switch may inform other devices in the DC network fabric **102** (e.g., additional switches) that other uses of the token, and therefore the IP address, have been revoked. In some examples, the first switch may be configured to inform the other devices directly. Additionally, or alternatively, the first switch may be configured to inform the other devices by employing the assistance of the DC authority **104** and/or the service controller **202**.

At **224**, the host **204** may now send from the address range matching the token. As such, at **226**, following validation of the token, the first switch may gain awareness that the host **204** has this address range and has the authorized validation to communicate on the address range. As such, incoming traffic to an address in the address range is received at the host **204** from the first switch. At **228**, the host **204** may then send the traffic into the service.

FIGS. **3** and **4** illustrate flow diagrams of example methods **300** and **400** and that illustrate aspects of the functions performed at least partly by the data center fabric **102**, the network controller **104**, and/or the service controller **202** as described in FIGS. **1**A, **1**B, and **2**. The logical operations described herein with respect to FIGS. **3** and **4** may be implemented (1) as a sequence of computer-implemented acts or program modules running on a computing system and/or (2) as interconnected machine logic circuits or circuit modules within the computing system. In some examples, the method(s) **300** and **400** may be performed by a system comprising one or more processors and one or more non-transitory computer-readable media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform the method(s) **300** and **400**.

The implementation of the various components described herein is a matter of choice dependent on the performance and other requirements of the computing system. Accordingly, the logical operations described herein are referred to variously as operations, structural devices, acts, or modules. These operations, structural devices, acts, and modules can be implemented in software, in firmware, in special purpose digital logic, and any combination thereof. It should also be appreciated that more or fewer operations might be performed than shown in the FIGS. **3** and **4** and described herein. These operations can also be performed in parallel, or in a different order than those described herein. Some or all of these operations can also be performed by components other than those specifically identified. Although the techniques described in this disclosure is with reference to specific components, in other examples, the techniques may be implemented by less components, more components, different components, or any configuration of components.

FIG. **3** illustrates a flow diagram of an example method **300** for a first device in a data center fabric **102** to receive a token comprising a verifiable indication of authorization to communicate on an address in the fabric, send one or more packets comprising the token to a second device in the data center fabric, and communicate on the address.

At **302**, the method **300** may include receiving a token at a first device in a data center fabric. In some examples, the token may comprise a verifiable indication of authorization to communicate on an address in the data center fabric **102**. In some examples, the token may be configured as the token **120** as described with respect to FIGS. **1**A-**2**.

At **304**, the method **300** may include sending one or more packets from the first device to a second device in the data center fabric **102**. In some examples, the one or more packets may include the token indicating the authorization to communicate on the address. In some examples, the first device may be configured as the first server **110**(**1**)(**1**) and the second device may be configured as the first switch **108**(**1**) as described with respect to FIGS. **1**A-**2**.

At **306**, the method **300** may include communicating, by the first device, data on the address. In some examples, a service executing on the first device may communicate the data on the address. In some examples, the service and/or the first device may send communication data to the second device, where the second device may be configured to route the communication data to additional devices in the data center network fabric **102**.

Additionally, or alternatively, the method **300** may include receiving the token from a network controller **104** associated with the data center fabric **102**. In some examples, the token may be signed using the private key of the network controller **104**.

Additionally, or alternatively, the method **300** may include signing the token using the private key of the first device to generate a signed token. In some examples, sending the one or more packets may include sending the signed token.

Additionally, or alternatively, the method **300** may include determining that the address is to be migrated to at least one of a different device or a different service. In some examples, the first device may determine that the address is to be migrated. Additionally, or alternatively, the method **300** may include signing, by the first device, an indication that the address is to be migrated to at least one of the different device or the different service. Additionally, or alternatively, the method **300** may include sending the indication into the data center fabric.

Additionally, or alternatively, the method **300** may include determining, by the first device, that the address is to be migrated to at least one of a different device or a different service. Additionally, or alternatively, the method **300** may include signing, by the first device, an indication that the address is to be migrated to at least one of the different device or the different service. Additionally, or alternatively, the method **300** may include sending the token to at least one of the different device or the different service.

Additionally, or alternatively, the method **300** may include sending, to one or more devices associated with the data center fabric, an indication that the authorization to communicate on the address has been transferred to at least one of the different device or the different service.

In some examples, the address may comprise at least one of an internet protocol (IP) address or a media access control (MAC) address.

FIG. **4** illustrates a flow diagram of an example method **400** for a network controller **104** associated with a data center fabric **102** to determine that a device in the data center fabric **102** is requesting to communicate on an address, sign a token indicating authorization to communicate on the address, and send the token to the device.

At **402**, the method **400** may include determining that a device in the data center fabric **102** is requesting to communicate on an address in the data center fabric **102**. In some examples, a network controller **104** associated with a data center fabric **102** may determine that the device in the data center fabric **102** is requesting to communicate on the address. In some examples, the device may be configured as the first server **110(1)(1)** or the first switch **108(1)** as described with respect to FIGS. **1A-2**.

At **404**, the method **400** may include signing a token indicating authorization to communicate on the address. Additionally, or alternatively, the method **400** may include creating the token by the network controller **104**. In some examples, the token may comprise a verifiable indication of authorization to communicate on an address in the data center fabric **102**. In some examples, the token may be configured as the token **120** as described with respect to FIGS. **1A-2**.

At **406**, the method **400** may include sending the token to the device. In some examples, the token may be sent from the network controller **104** to the first device. Additionally, or alternatively, the token may be sent from an additional device included in the data center network fabric **102** and to the first device.

In some examples, the address may comprise at least one of an internet protocol (IP) address or a media access control (MAC) address.

Additionally, or alternatively, the method **400** may include receiving a request from the device to transfer the authorization to communicate on the address to an additional device in the data center fabric. Additionally, or alternatively, the method **400** may include signing an additional token indicating authorization to communicate on the address. Additionally, or alternatively, the method **400** may include sending the additional token to the additional device.

Additionally, or alternatively, the method **400** may include receiving a request from the device to transfer the authorization to communicate on the address to an additional device in the data center fabric. Additionally, or alternatively, the method **400** may include sending, to one or more devices associated with the data center fabric, an indication that the authorization to communicate on the address is to be transferred from the device to the additional device.

In some examples, signing the token may comprise signing the token using a private key of the network controller.

Additionally, or alternatively, the method **400** may include determining, by the network controller, that the address is to be migrated to at least one of a different device or a different service. Additionally, or alternatively, the method **400** may include signing, by the network controller, an indication that the address is to be migrated to at least one of the different device or the different service. Additionally, or alternatively, the method **400** may include sending the indication into the data center fabric. Additionally, or alternatively, the method **400** may include sending the token to at least one of the different device or the different service.

FIG. **5** is a computing system diagram illustrating a configuration for a data center **500** that can be utilized to implement aspects of the technologies disclosed herein. The example data center **500** shown in FIG. **5** includes several server computers **502**A-**502**E (which might be referred to herein singularly as "a server computer **502**" or in the plural as "the server computers **502**") for providing computing resources. In some examples, the server computers **502** may include, or correspond to, the servers described herein with respect to FIG. **1**.

The server computers **502** can be standard tower, rack-mount, or blade server computers configured appropriately for providing the computing resources described herein. As mentioned above, the computing resources provided by the data center network fabric **102** can be data processing resources such as VM instances or hardware computing systems, database clusters, computing clusters, storage clusters, data storage resources, database resources, networking resources, and others. Some of the servers **502** can also be configured to execute a resource manager capable of instantiating and/or managing the computing resources. In the case of VM instances, for example, the resource manager can be a hypervisor or another type of program configured to enable the execution of multiple VM instances on a single server computer **502**. Server computers **502** in the data center **500** can also be configured to provide network services and other types of services.

In the example data center **500** shown in FIG. **5**, an appropriate LAN **508** is also utilized to interconnect the server computers **502**A-**502**E. It should be appreciated that the configuration and network topology described herein has been greatly simplified and that many more computing systems, software components, networks, and networking devices can be utilized to interconnect the various computing systems disclosed herein and to provide the functionality described above. Appropriate load balancing devices or other types of network infrastructure components can also be utilized for balancing a load between data centers **500**, between each of the server computers **502**A-**502**E in each data center **500**, and, potentially, between computing resources in each of the server computers **502**. It should be appreciated that the configuration of the data center **500** described with reference to FIG. **5** is merely illustrative and that other implementations can be utilized.

In some examples, the server computers **502** may each execute one or more network switch(es) **504**, the service(s) **112**, and/or the host(s) **204**, provisioned across a set or cluster of servers **502**.

In some instances, the data center network fabric **102** may provide computing resources, like application containers, VM instances, and storage, on a permanent or an as-needed basis. Among other types of functionality, the computing resources provided by the data center network fabric **102** may be utilized to implement the various services described above. The computing resources provided by the data center network fabric **102** can include various types of computing resources, such as data processing resources like application containers and VM instances, data storage resources, networking resources, data communication resources, network services, and the like.

Each type of computing resource provided by the data center network fabric **102** can be general-purpose or can be available in a number of specific configurations. For example, data processing resources can be available as physical computers or VM instances in a number of different configurations. The VM instances can be configured to execute applications, including web servers, application servers, media servers, database servers, some or all of the network services described above, and/or other types of programs. Data storage resources can include file storage devices, block storage devices, and the like. The computing resources network **102** can also be configured to provide other types of computing resources not mentioned specifically herein.

The computing resources provided by the data center network fabric **102** may be enabled in one embodiment by one or more data centers **500** (which might be referred to herein singularly as "a data center **500**" or in the plural as "the data centers **500**"). The data centers **500** are facilities utilized to house and operate computer systems and associated components. The data centers **500** typically include redundant and backup power, communications, cooling, and security systems. The data centers **500** can also be located in geographically disparate locations. One illustrative embodiment for a data center **500** that can be utilized to implement the technologies disclosed herein will be described below with regard to FIG. **5**.

FIG. **6** shows an example computer architecture for a computing device (or network switch) **502** capable of executing program components for implementing the functionality described above. The computer architecture shown in FIG. **6** illustrates a conventional server computer, workstation, desktop computer, laptop, tablet, network appliance, e-reader, smartphone, or other computing device, and can be utilized to execute any of the software components presented herein. The computing device **502** may, in some examples, correspond to a physical server **116** described herein with respect to FIG. **1**.

The computing device **502** includes a baseboard **602**, or "motherboard," which is a printed circuit board to which a multitude of components or devices can be connected by way of a system bus or other electrical communication paths. In one illustrative configuration, one or more central processing units ("CPUs") **604** operate in conjunction with a chipset **606**. The CPUs **604** can be standard programmable processors that perform arithmetic and logical operations necessary for the operation of the computing device **502**.

The CPUs **604** perform operations by transitioning from one discrete, physical state to the next through the manipulation of switching elements that differentiate between and change these states. Switching elements generally include electronic circuits that maintain one of two binary states, such as flip-flops, and electronic circuits that provide an output state based on the logical combination of the states of one or more other switching elements, such as logic gates. These basic switching elements can be combined to create more complex logic circuits, including registers, adders-subtractors, arithmetic logic units, floating-point units, and the like.

The chipset **606** provides an interface between the CPUs **604** and the remainder of the components and devices on the baseboard **602**. The chipset **606** can provide an interface to a RAM **608**, used as the main memory in the computing device **502**. The chipset **606** can further provide an interface to a computer-readable storage medium such as a read-only memory ("ROM") **610** or non-volatile RAM ("NVRAM") for storing basic routines that help to startup the computing device **502** and to transfer information between the various components and devices. The ROM **610** or NVRAM can also store other software components necessary for the operation of the computing device **502** in accordance with the configurations described herein.

The computing device **502** can operate in a networked environment using logical connections to remote computing devices and computer systems through a network, such as the network **116**. The chipset **606** can include functionality for providing network connectivity through a NIC **612**, such as a gigabit Ethernet adapter. The NIC **612** is capable of connecting the computing device **502** to other computing devices over the network **116**. It should be appreciated that multiple NICs **612** can be present in the computing device **502**, connecting the computer to other types of networks and remote computer systems.

The computing device **502** can be connected to a storage device **618** that provides non-volatile storage for the computing device **502**. The storage device **618** can store an operating system **620**, programs **622**, and data, which have been described in greater detail herein. The storage device **618** can be connected to the computing device **502** through a storage controller **614** connected to the chipset **606**. The storage device **618** can consist of one or more physical storage units. The storage controller **614** can interface with the physical storage units through a serial attached SCSI ("SAS") interface, a serial advanced technology attachment ("SATA") interface, a fiber channel ("FC") interface, or other type of interface for physically connecting and transferring data between computers and physical storage units.

The computing device **502** can store data on the storage device **618** by transforming the physical state of the physical storage units to reflect the information being stored. The specific transformation of physical state can depend on various factors, in different embodiments of this description. Examples of such factors can include, but are not limited to, the technology used to implement the physical storage units, whether the storage device **618** is characterized as primary or secondary storage, and the like.

For example, the computing device **502** can store information to the storage device **618** by issuing instructions through the storage controller **614** to alter the magnetic characteristics of a particular location within a magnetic disk drive unit, the reflective or refractive characteristics of a particular location in an optical storage unit, or the electrical characteristics of a particular capacitor, transistor, or other discrete component in a solid-state storage unit. Other transformations of physical media are possible without departing from the scope and spirit of the present description, with the foregoing examples provided only to facilitate this description. The computing device **502** can further read information from the storage device **618** by detecting the physical states or characteristics of one or more particular locations within the physical storage units.

In addition to the mass storage device **618** described above, the computing device **502** can have access to other computer-readable storage media to store and retrieve information, such as program modules, data structures, or other data. It should be appreciated by those skilled in the art that computer-readable storage media is any available media that provides for the non-transitory storage of data and that can be accessed by the computing device **502**. In some examples, the operations performed by the data center network fabric **102**, and or any components included therein, may be supported by one or more devices similar to computing device **502**. Stated otherwise, some or all of the operations performed by the data center network fabric **102**, and or any components included therein, may be performed by one or more computing device **502** operating in a cloud-based arrangement.

By way of example, and not limitation, computer-readable storage media can include volatile and non-volatile, removable and non-removable media implemented in any method or technology. Computer-readable storage media includes, but is not limited to, RAM, ROM, erasable programmable ROM ("EPROM"), electrically-erasable programmable ROM ("EEPROM"), flash memory or other solid-state memory technology, compact disc ROM ("CD-ROM"), digital versatile disk ("DVD"), high definition DVD ("HD-DVD"), BLU-RAY, or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to store the desired information in a non-transitory fashion.

As mentioned briefly above, the storage device **618** can store an operating system **620** utilized to control the operation of the computing device **502**. According to one embodiment, the operating system comprises the LINUX operating system. According to another embodiment, the operating system comprises the WINDOWS® SERVER operating system from MICROSOFT Corporation of Redmond, Washington According to further embodiments, the operating system can comprise the UNIX operating system or one of its variants. It should be appreciated that other operating systems can also be utilized. The storage device **618** can store other system or application programs and data utilized by the computing device **502**.

In one embodiment, the storage device **618** or other computer-readable storage media is encoded with computer-executable instructions which, when loaded into the computing device **502**, transform the computer from a general-purpose computing system into a special-purpose computer capable of implementing the embodiments described herein. These computer-executable instructions transform the computing device **502** by specifying how the CPUs **604** transition between states, as described above. According to one embodiment, the computing device **502** has access to computer-readable storage media storing computer-executable instructions which, when executed by the computing device **502**, perform the various processes described above with regard to FIGS. **1-4**. The computing device **502** can also include computer-readable storage media having instructions stored thereupon for performing any of the other computer-implemented operations described herein.

The computing device **502** can also include one or more input/output controllers **616** for receiving and processing input from a number of input devices, such as a keyboard, a mouse, a touchpad, a touch screen, an electronic stylus, or other type of input device. Similarly, an input/output controller **616** can provide output to a display, such as a computer monitor, a flat-panel display, a digital projector, a printer, or other type of output device. It will be appreciated that the computing device **502** might not include all of the components shown in FIG. **5**, can include other components that are not explicitly shown in FIG. **5**, or might utilize an architecture completely different than that shown in FIG. **5**.

The server computer **502** may be configured to communicate with the network controller **104** and/or one or more leaf switches **108**. At "1," the server computer **502** and/or an associated leaf switch **108** may receive a token representing a validated authorization to communicate on an address in the data center network fabric. At "2," the server computer **502** may send one or more packets including the token to an associated leaf switch **108**. The leaf switch **108** may then validate the token, and the server computer **502** may then be allowed to communicate data on the address.

While the invention is described with respect to the specific examples, it is to be understood that the scope of the invention is not limited to these specific examples. Since other modifications and changes varied to fit particular operating requirements and environments will be apparent to those skilled in the art, the invention is not considered limited to the example chosen for purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of this invention.

Although the application describes embodiments having specific structural features and/or methodological acts, it is to be understood that the claims are not necessarily limited to the specific features or acts described. Rather, the specific features and acts are merely illustrative some embodiments that fall within the scope of the claims of the application.

What is claimed is:

1. A method comprising:

preventing a first server among servers in a data center fabric from communicating data from a range of addresses of a switch in the data center fabric, the switch providing switching services to the servers in the data center fabric;

determining that a service has been instantiated on the first server;

receiving a token at the first server, the token comprising a verifiable indication of authorization allowing the service to communicate from the range of addresses in the data center fabric;

sending one or more packets from the first server to the switch, the one or more packets including the token indicating the authorization allowing the service to communicate from the range of addresses;

communicating, by the first server, the data from a first address included in the range of addresses; and preventing the first server from communicating the data from a second address that is outside of the range of addresses.

2. The method of claim **1**, further comprising receiving the token from a network controller associated with the data center fabric, wherein the token is signed using a private key of the network controller.

3. The method of claim **1**, further comprising signing the token using a private key of the first server to generate a signed token, wherein sending the one or more packets includes sending the signed token.

4. The method of claim **1**, further comprising:

determining, by the first server, that the range of addresses is to be migrated to at least one of a different device or a different service;

signing, by the first server, an indication that the range of addresses is to be migrated to at least one of the different device or the different service; and

sending the indication into the data center fabric.

5. The method of claim **1**, further comprising:

determining, by the first server, that the range of addresses is to be migrated to at least one of a different device or a different service;

signing, by the first server, an indication that the range of addresses is to be migrated to at least one of the different device or the different service; and

sending the token to at least one of the different device or the different service.

6. The method of claim **5**, further comprising sending, to one or more devices associated with the data center fabric, an indication that the authorization to communicate from the range of addresses has been transferred to at least one of the different device or the different service.

7. The method of claim **1**, wherein the first address comprises at least one of an internet protocol (IP) address or a media access control (MAC) address.

8. A system comprising:

one or more processors; and

one or more non-transitory computer-readable media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform operations comprising:

preventing a first server among servers in a data center fabric from communicating data from a range of addresses of a switch in the data center fabric, the switch providing switching services to the servers in the data center fabric;

determining that a service has been instantiated on the first server;

receiving a token at the first server, the token comprising a verifiable indication of authorization allowing the service to communicate from a range of addresses in the data center fabric;

sending one or more packets from the first server to the switch in the data center fabric, the one or more packets including the token indicating the authorization allowing the service to communicate from the range of addresses;

communicating the data from a first address included in the range of addresses by the server; and

preventing the data from being communicated from a second address that is outside of the range of addresses.

9. The system of claim **8**, the operations further comprising receiving the token from a network controller associated with the data center fabric, wherein the token is signed using a private key of the network controller.

10. The system of claim **8**, the operations further comprising signing the token using a private key of the first server to generate a signed token, wherein sending the one or more packets includes sending the signed token.

11. The system of claim **8**, wherein the first address comprises at least one of an internet protocol (IP) address or a media access control (MAC) address.

12. The system of claim **8**, the operations further comprising:

determining, by the first server, that the range of addresses is to be migrated to at least one of a different device or a different service;

signing, by the first server, an indication that the range of addresses is to be migrated to at least one of the different device or the different service; and

sending the indication into the data center fabric.

13. The system of claim **8**, the operations further comprising:

determining, by the first server, that the range of addresses is to be migrated to at least one of a different device or a different service;

signing, by the first server, an indication that the range of addresses is to be migrated to at least one of the different device or the different service; and

sending the token to at least one of the different device or the different service.

14. The system of claim **13**, the operations further comprising sending, to one or more devices associated with the data center fabric, an indication that the authorization to communicate from the range of addresses has been transferred to at least one of the different device or the different service.

15. A method comprising:

allowing, by a network controller associated with a data center fabric, a switch in the data center fabric to provide switching services to servers in the data center fabric;

preventing, by the network controller, a first server in the data center fabric from communicating data from a range of addresses in the data center fabric;

determining, by the network controller associated with the data center fabric, that a service executing on the first server in the data center fabric is requesting to communicate from the range of addresses in the data center fabric;

signing a token indicating authorization allowing the service to communicate from the range of addresses; and

sending the token to the first server, the token being utilized by a switch in the data center fabric to (i) communicate the data from the first server from a first address included in the range of addresses on behalf of the service and (ii) prevent the service from communicating data from the first server from a second address that is outside of the range of addresses.

16. The method of claim **15**, wherein an address included in the range of addresses comprises at least one of an internet protocol (IP) address or a media access control (MAC) address.

17. The method of claim **15**, further comprising: receiving a request from the first server to transfer the authorization to communicate on the range of addresses to an additional second server in the data center fabric; signing an additional token indicating authorization to communicate from the range of addresses; and sending the additional token to the additional second server.

18. The method of claim **15**, wherein: receiving a request from the first server to transfer the authorization to communicate from the range of addresses to an additional a second server in the data center fabric; and sending, to one or more of the servers associated with the data center fabric, an indication that the authorization to communicate from the range of addresses is to be transferred from the first server to the additional second server.

19. The method of claim **15**, wherein signing the token comprises signing the token using a private key of the network controller.

20. The method of claim **15**, further comprising: determining, by the network controller, that the range of addresses is to be migrated to at least one of a different device or a different service; signing, by the network controller, an indication that the range of addresses is to be migrated to at least one of the different device or the different service; sending the indication into the data center fabric; and sending the token to at least one of the different device or the different service.

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